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Editorial

There was a time, not that long ago, when the preface for a journal special issue on "multiagent systems" would require a definition of that term and a justification for why such systems are important to study. As recently as the mid-1990s, as the First International Conference on MultiAgent Systems (ICMAS'95) was being organized by relatively small research communities in America, Europe, and Asia, the field had the flavor of being an interesting but peripheral undertaking compared to the primary concerns of artificial intelligence.

Times have certainly changed! For a variety of reasons, including the ubiquity of networked computing systems, practical applications of those systems in areas like electronic commerce and digital libraries, and the consequent recognition that complex software systems will ultimately be comprised of sophisticated components with relationships that undergo ongoing redefinition and negotiation, multiagent systems have become much more of a central concern. Concurrently, there has been an explosion of interest in multiple agents in virtual environments, in games, and in robotic applications (such as RoboCup). This evolution is evidenced in the growth of the community of researchers now involved in multiagent system research: the small initial core of researchers has been enriched by many others who previously had concentrated in areas such as machine learning, planning, and reasoning under uncertainty, and who have come to recognize the challenge and importance of those concerns in the context of multiagent systems. Multiagent initiatives and projects have taken root in corporate, government, and academic settings.

At the beginning of a new century and millennium, therefore, the multiagent systems field is recognized as holding promise for improving our understanding about how complex interactions can be understood and harnessed to help us meet technological and social needs. The ICMAS-2000 Conference, held in Boston in July of 2000, gave a snapshot of the best contemporary work in the field, both in terms of full papers that described research results in some detail, and briefer abstracts that could herald up-and-coming breakthroughs in the field. The papers suggested the diversity of ideas, methodologies, theories, and applications associated with the field. Many of these have only taken shape in recent years, and were unforeseen even as recently as at the first ICMAS in 1995. As the research challenges and insights continue to evolve, it is a certainty that the field will continue to thrive on the diverse contributions of the many researchers who are bound together by their mutual interest in understanding the phenomena that arise when agents interact, in investigating the interplay between agents as individuals and as participants in collective

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settings, and in formulating languages, architectures, mechanisms, and engineering and evaluation methodologies that apply to multiagent systems.

The Fourth International Conference on MultiAgent Systems (ICMAS-2000) continued the ICMAS tradition of presenting papers of the highest quality. Of the 220 papers received, 42 were selected for full presentation, an acceptance rate of only 19%, sustaining the selectivity trend established by ICMAS'98 (23%), ICMAS'96 (28%) and ICMAS'95 (33%). From that very selective group of accepted papers, we chose (based on reviewer opinions and our own evaluations) a subset of 14 to invite to this special issue. In turn, the extended versions of the papers were carefully reviewed by experts in the field, resulting in the final selection of the seven papers included in this special issue. We are indebted to the many reviewers, as well as to the editorial staff who oversaw the process, most notably Jennet Batten.

The papers in this special issue thus represent work in multiagent systems that is of the highest quality. These papers describe advances and results that are of significant interest to the multiagent systems community, and we believe of interest to the Artificial Intelligence community more broadly. As summarized in the following paragraphs, the papers span issues ranging from achieving emergent and intentional cooperative action among agents, to promoting effective decision-making and negotiation among self-interested agents.

Reconfigurable or metamorphic robots form an exciting frontier of multiagent systems research, and specifically for cooperative multiagent systems. Essentially, using distributed control, multiple modules of a single robot must attach and detach to change the robot's shape to suit different tasks. Key constraints on such distributed control mechanisms are that the different modules can only communicate in a limited fashion with their neighbors, and there is very limited computational power available per module. Bojinov, Casal, and Hogg present work on agent-based control of such metamorphic robots, where modules combine to form "emergent" structures. To accomplish this challenging task, they focus on simple agent-based control, using local rules and sensing.

Tonino, Bos, de Weerdt, and Witteveen provide a framework and algorithms that agents can use to coordinate their plans. They consider two purposes for plan coordination: each agent can try to maximize the total benefits to all of the agents, or each agent can aim at maximizing only its own benefits. In both cases, coordination is achieved through iterative plan revision processes, and Tonino et al. present polynomial algorithms for these iterative processes.

Grosz, Kraus, Sullivan, and Das also investigate the issues of coordinated activity, but with an emphasis on commitments. Even within collaborative contexts, agents may need to revise their commitments to their team, as agents may face new opportunities that may conflict with their team-related commitments; yet agents cannot adopt conflicting commitments. This work uses the SPIRE (SharedPlan Intention Reconciliation Experiment) simulation system for a careful experimental investigation of such conflicting commitments. In particular, using SPIRE, Grosz et al. investigate the impact of social commitment policies, i.e., domain-independent social norms, as well as environmental factors, on an agent's decision making.

Sen's article is also focused on multiagent cooperation, but it focuses on strategies that promote cooperation within a group of agents. The roots of this work are in Axelrod's seminal work on evolution of cooperative behavior in self-interested agents, based on

notions of reciprocity (e.g., an agent reciprocates to another agent who has cooperated in the past). Building on this work, Sen proposes techniques to avoid exploitation of reciprocative agents in a group by selfish (non-reciprocative) agents in that group. In particular, by sharing "word-of-mouth" reputation information, reciprocative agents limit the exploitation by selfish agents.

Negotiation is an important way for agents to reach mutually beneficial agreements. Faratin, Sierra, and Jennings present a negotiation strategy, called the *trade-off* strategy, for multi-issue negotiation. Following this strategy, the agents make tradeoffs between negotiation decision variables. Faratin et al. present a novel linear algorithm that enables the agents to make tradeoffs between both discrete and continuous negotiation decision variables, in the presence of information uncertainty and bounded resources.

Sandholm and Zhou also focus on negotiations for self-interested agents. Their work is in the tradition of "market-based" approaches to multiagent systems. Specifically, they focus on leveled commitment contracts, where agents may backtrack on a contract by paying a penalty; this contrasts with earlier work where full-commitment contracts between self-interested agents are completely binding. In this paper, they investigate and compare six different leveled commitment contracting mechanisms.

E-commerce is one of the direct application areas of multiagent technologies. Matsubara and Yokoo are working on theoretical bases for auction mechanisms and have developed safe exchange mechanisms for goods and money. They have introduced mechanisms based on imposition of entry fees, which can contribute to solving online-fraud problems on the Internet. One of the advantages of these mechanisms is that they can balance the conflict between safety and convenience, namely by reducing the entry fee without compromising safety.

As it turns out, the success of ICMAS-2000 helped trigger an investigation into whether the several strong conferences for reporting agent research should consolidate their efforts. As a result, for 2002, ICMAS joined forces with the ACM Conference on Autonomous Agents, and the long-running series of ATAL (Agent Theory, Architecture, and Languages) workshops, to hold the First Autonomous Agents and Multi-Agent Systems (AAMAS) conference in Bologna in July of 2002. That conference was attended by approximately 700 people, encouraging the continued alliance for subsequent AAMAS conferences in the upcoming years. We look forward to seeing the continued production of excellent advances in this important field presented at those conferences, and hope that the papers in this issue encourage even greater awareness and participation.

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